

# University of Iowa

# Introduction

Cochlear Implants (CIs) restore a sense of sound to individuals with profound hearing loss through electric stimulation of the auditory nerve

 Different device configurations may maintain residual acoustic hearing

CI users must learn to adapt to the novel input from their CI, which is spectrally degraded compared to acoustic hearing

The change in auditory quality impacts how words are recognized

Generally, word recognition begins immediately and proceeds incrementally (Allopenna et al., 1998; Marslen-Wilson, 1987)

In CI users, lexical access is delayed, leading to differences in how competition is resolved between competitors (Farris-Trimble et al., 2014; McMurray et al., 2017)

- Wait-and-See: characterized by slower activation of candidates, reduced competition (see PC1)
- Sustained activation: characterized by increased activation of cohort competitors for longer than typical (see PC2)

CI users report increased effort and fatigue during language processing, but effort is not clearly related to better accuracy (Hughes et al., 2018; Perreau et al., 2017; Winn et al., 2015)

# **Research Questions**

What are the underlying dimensions of real-time word recognition among CI users?

Does listening effort affect the underlying processes of word recognition (as opposed to accuracy) in CI users?

Do CI users need effort to adopt a given processing profile? Or to overcome it?

# Methods

#### **Participants** (N = 81)

Hearing Configuration	Count	Mean Age (SD) in years	Time Since Intervention (SD) in years
Electric-Only			
Unilateral CI	17	52.8 (15.9)	12.8 (9.7)
Bilateral CI	15	49.5 (17.7)	7.2 (6.1)
Acoustic + Electric			
Bimodal CI	19	56.4 (19.4)	5.2 (4.7)
Hybrid CI	30	59.9 (12.6)	6.4 (3.5)

#### **Experiments**

#### **Spectral Ripple and Temporal Modulation** Discrimination

Measures of auditory fidelity

Adaptive 3-alternate forced choice oddball task implemented with UML (75 trials each) (Shen et al., 2015)

**Spectral Ripple:** Broadband noise with amplitude-depthmodulated ripples. Ripples/octave held constant.

**Temporal Modulation:** Complex tone with superimposed sine wave that is amplitude modulated

# Engaging Effort Improves Efficiency during Word Recognition in Cochlear Implant Users

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#### **Experiments**

#### Visual World Paradigm (VWP)

Participants click on the picture that best matches the word they heard

Visual display presents target, cohort, rhyme, and unrelated item (e.g., sandal, sandwich, candle, penguin)

60 item sets x 4 items/set x 1.25 repetitions/set = 300 trials (Each item from a set is the target word once + one randomly repeated)

#### **Principle Component Analysis**

Used to identify orthogonal dimensions from parameters of non-linear curves fit to VWP data



#### **Pupillometry**

read (Speech vs. Text conditions)

unrelated item (e.g., coat, comb, goat, lips)

the onset of the target word in both conditions.





# Results

Temporal Modulation

Linear regression:

Principle Component	Listening Config.	Pupil size	Spectral Ripple	Temporal Mod.	Spectral Ripple x Pupil	Temp. Mod. x Pupil
Wait and See	×	$\checkmark$		×	~	×
Sustained Activation	×	×	×	×	×	×
Activation Rate	×	×	×		×	×



# Summary and Conclusions

Previously hypothesized profiles of word recognition (Wait and See, Sustained Activation) emerge as principle components across a large, variable sample

Sustained activation is not related to any tested variables

Could be relevant to device or language experience?

Activation rate predicted by temporal modulation

- Individuals with better discrimination are faster to activate words
- Both activation rate and temporal cue fidelity tied to aging

Wait and See predicted by effort and spectral ripple

- Individuals with better auditory fidelity show less wait-and-see during word recognition
- Effort can be engaged to offset wait-andsee during word recognition Better auditory fidelity offsets need to
- engage effort

# **2pSC21**

#### Principle components from VWP predicted by listening configuration (A+E vs. E-only), pupil size difference score, and principle components encompassing Spectral Ripple and

#### Prinicple component ~ Listening configuration + pupil x (Spectral Ripple + Temporal Mod.)







#### **Acknowledgments & References**

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